Chrome-Free Paint Primer for Zn/Ni Plated High-Strength Steel

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Presentation at ASETSDefense 2014

George Zafiris

Team: Mark Jaworowski, Mike Kryzman, Marilea Manzini, Roque Panza-Giosa, George Zafiris, Weilong Zhang

United Technologies Research Center (UTRC), and

United Technologies Aerospace Systems/Landing Gear (UTAS/LG)

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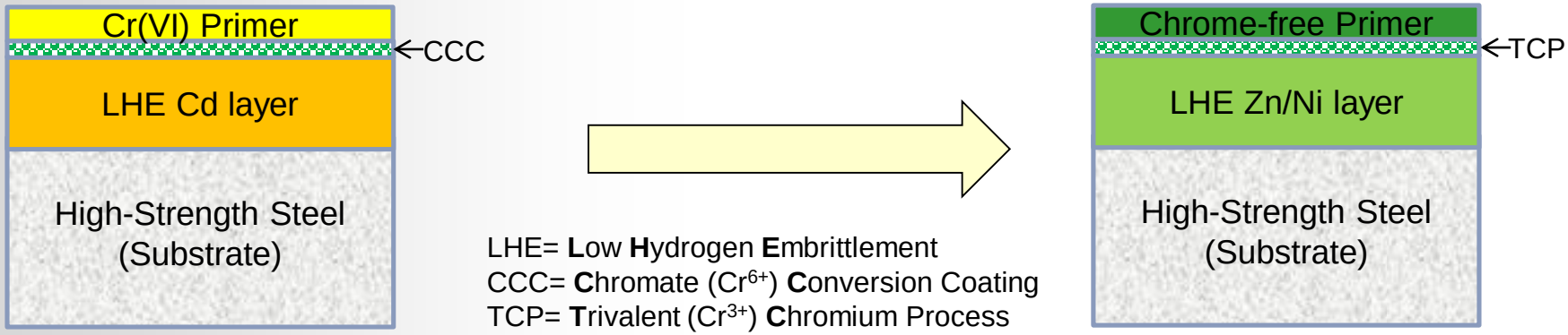
Background

- *Regulatory EHS restrictions on use of chromates and Cd*
- *Strontium chromate sunset in EU - REACH: 2017*
- *LHE ZnNi replacing LHE Cd in military and commercial landing gear systems*



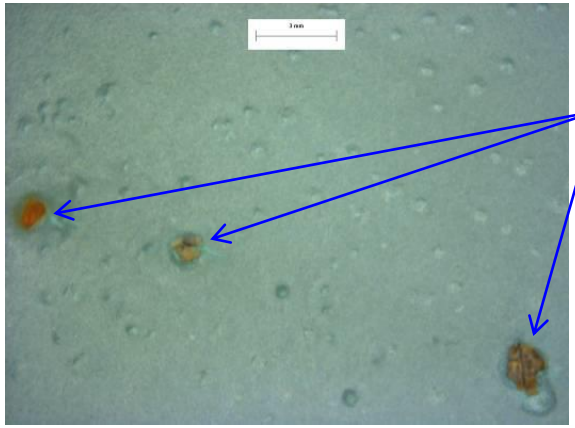
LHE= **L**ow **H**ydrogen **E**mbrittlement
CCC= **C**hromate (Cr^{6+}) **C**onversion Coating
TCP= **T**rivalent (Cr^{3+}) **C**hromium Process

Chrome-free Primer for Steel

Commercial primers (most developed for aluminum) do not provide adequate corrosion inhibition for LHE ZnNi or Cd plated low alloy steels

After 1,700hrs ASTM B117

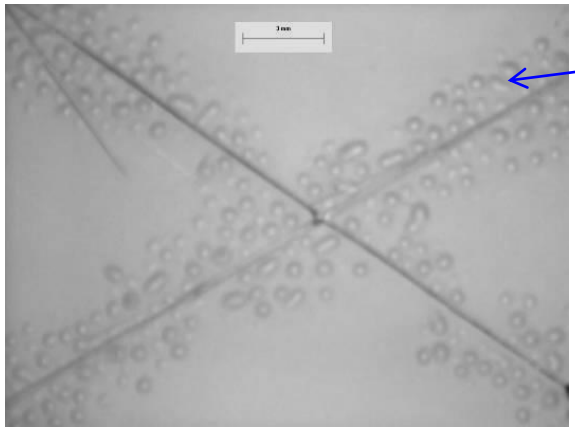
Commercial solvent-based Epoxy primer



Blisters and Red Rust

After 2,300hrs ASTM B117

Commercial solvent-based Epoxy primer



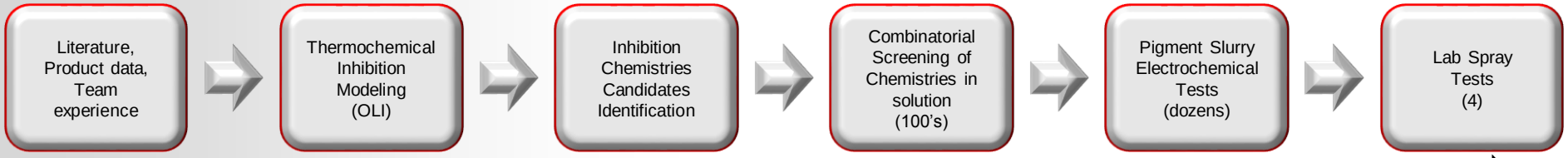
Blisters Only

No rust underneath

Approach

Primer technology development steps:

- *Corrosion inhibitor chemistries modeling and high-throughput screening in solution*
- *Promising inhibitor chemistries assessment utilizing DC potentiodynamic techniques*
- *Inhibitor chemistries down-selection and translation to pigment form*
- *Pigment formulation development and potentiodynamic testing in slurry form for effective release (solubility) and inhibition*
- *Inhibitor pigment incorporation in resin for salt-fog corrosion evaluation*
- *Physical and chemical properties evaluation (adhesion, fluids, solvents resistance, impact, topcoat compatibility, etc.)*
- *Field validation and industrialization*



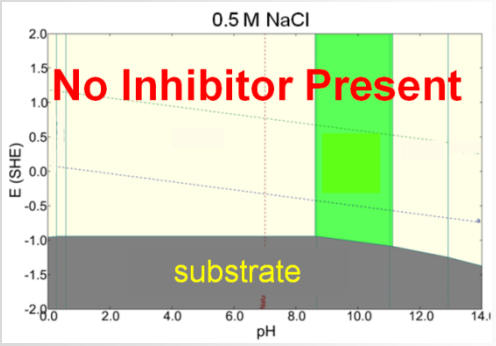
From inhibitor chemistry identification to pigment formulation development and primer testing

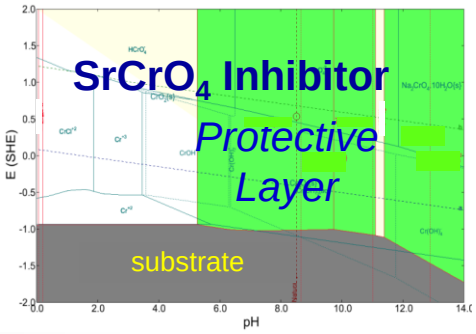
High-Throughput Inhibitor Screening

Rapid inhibitor chemistries screening in solution

***Approach**:*

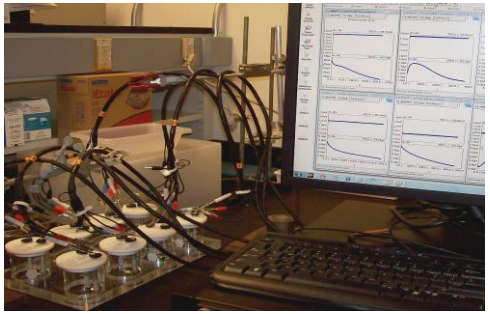
- *High-throughput inhibition measurement:*
  - ➢ *10 min/sample vs. 3-4 hrs/sample for DC polarization*
- *Screen candidate chemistries for inhibition in solution vs. chromate control vs. non-inhibited electrolyte baseline*
- *Statistical design of experiments (DOE) to identify effects, and develop and optimize formulation*
- *Thermochemical modeling (OLI) for inhibition space prediction and candidate virtual-space screening*
- *Pigment solubility prediction: OLI software*



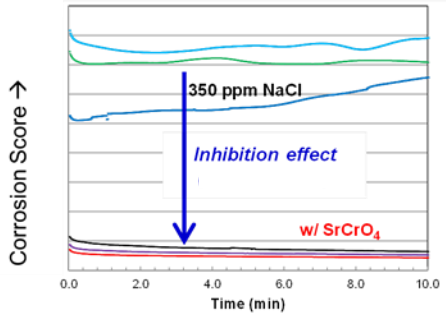


- *Utilize potentiodynamic measurement for confirmation and detailed characterization of inhibitor*

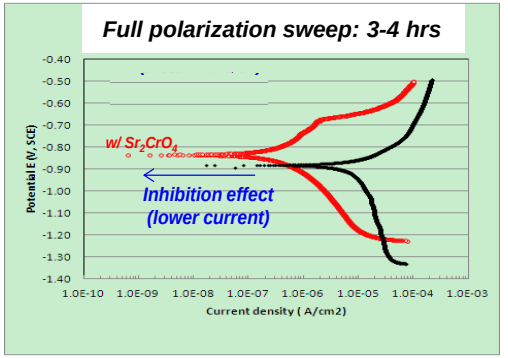
Multi-potentiostat test station



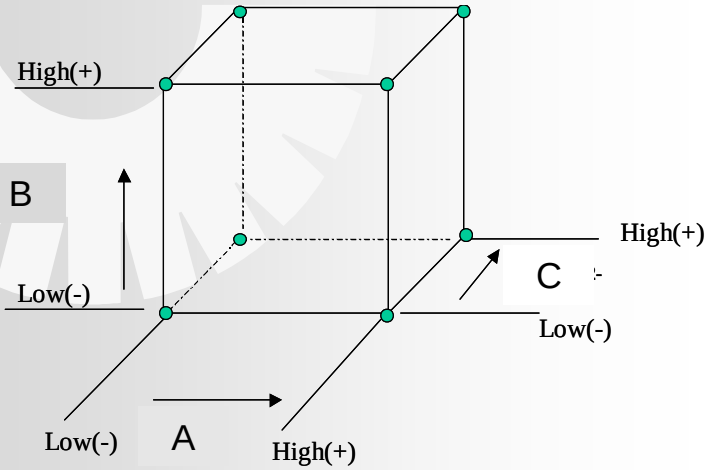
Inhibition current measurement: 10 min

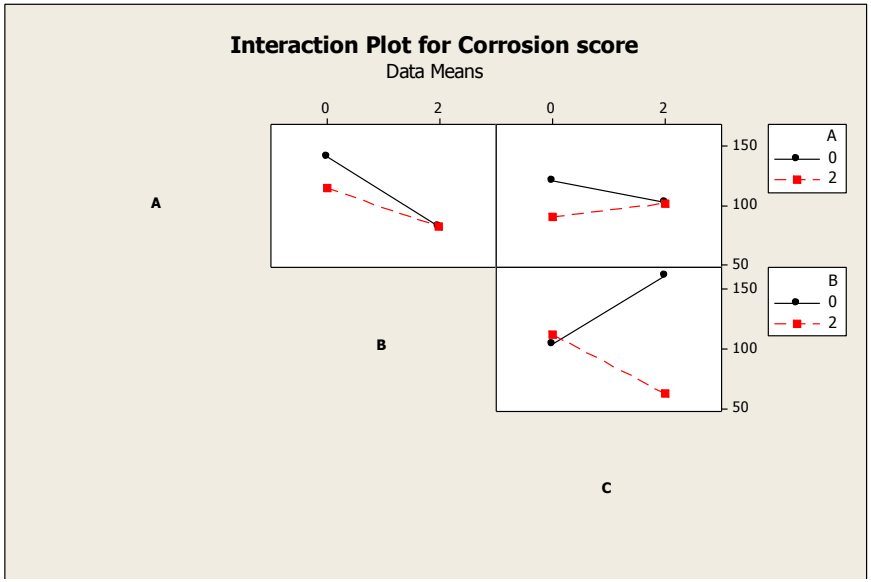


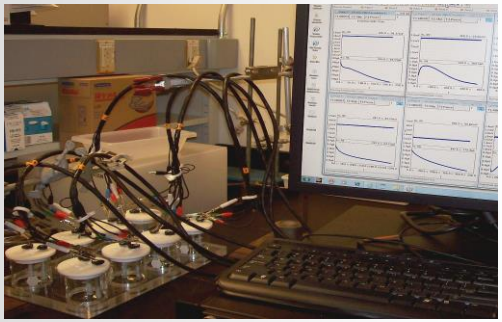
Full polarization sweep: 3-4 hrs

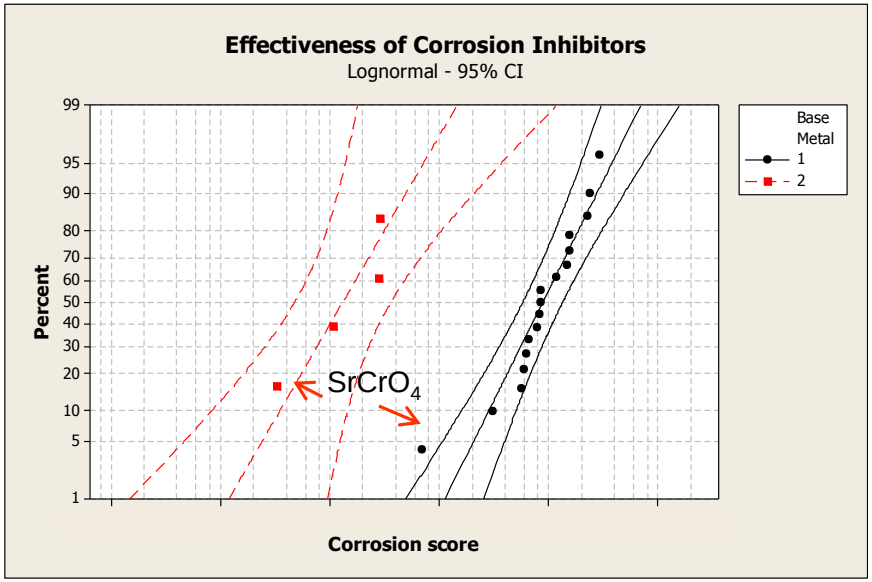


High-Throughput Inhibitor Screening Methodology



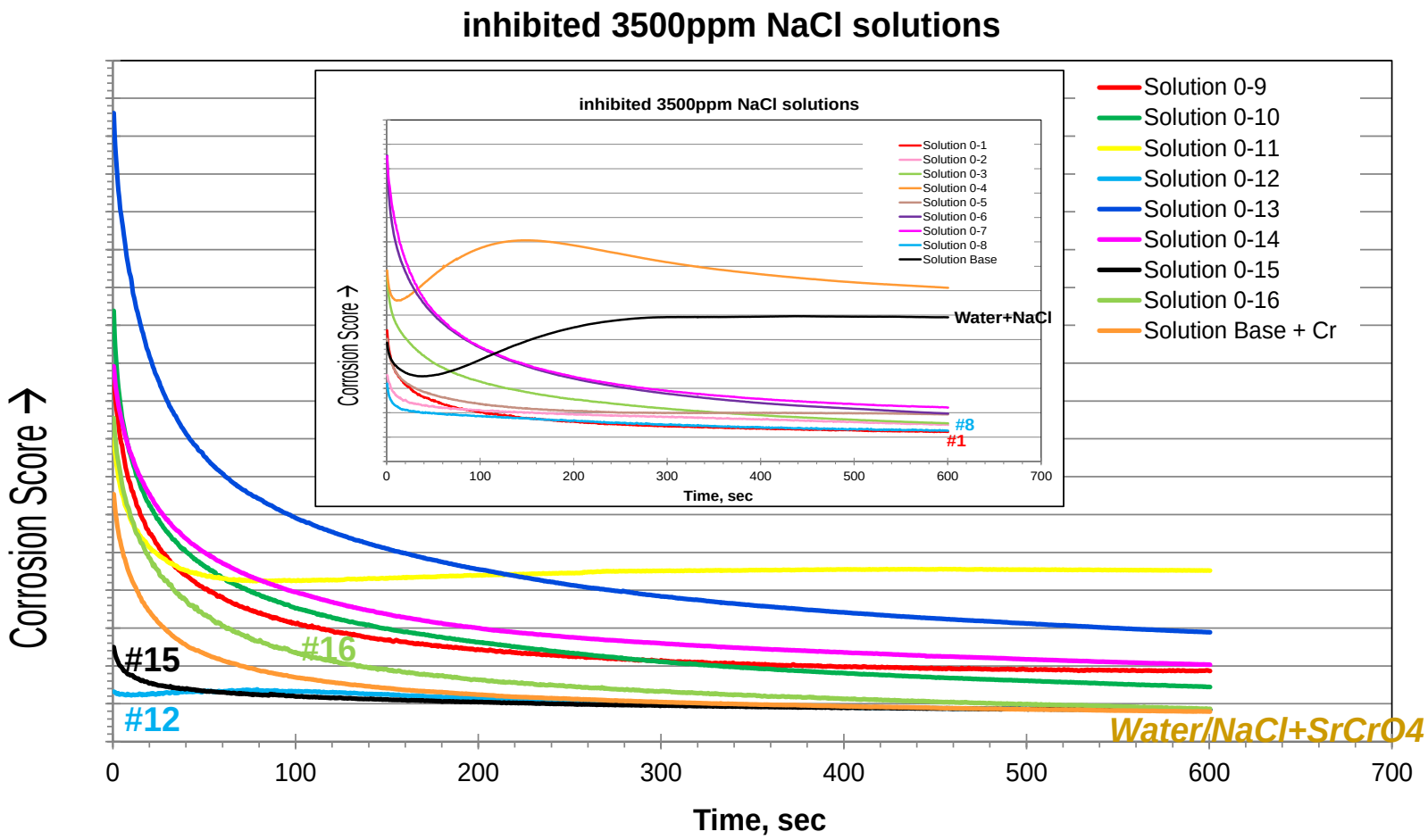






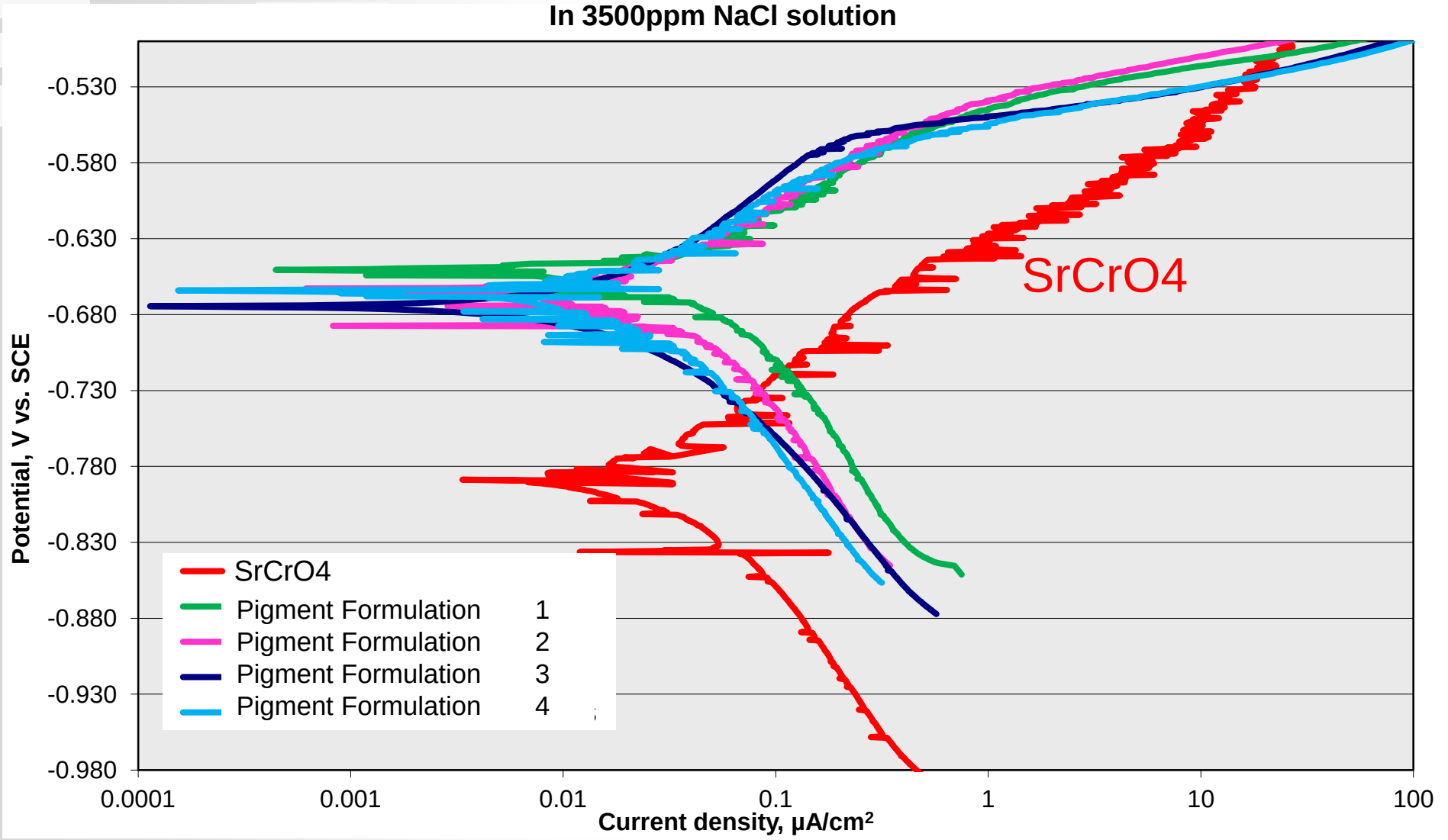
High-throughput Inhibitor Chemistries Screening

- *DOE designs used to screen and determine main factors*
- *Once critical x's determined RS DOEs executed to refine inhibitor formulation*



Promising Inhibitor Formulations in Pigment Form

Potentiodynamic testing of leading pigment formulations in slurry form

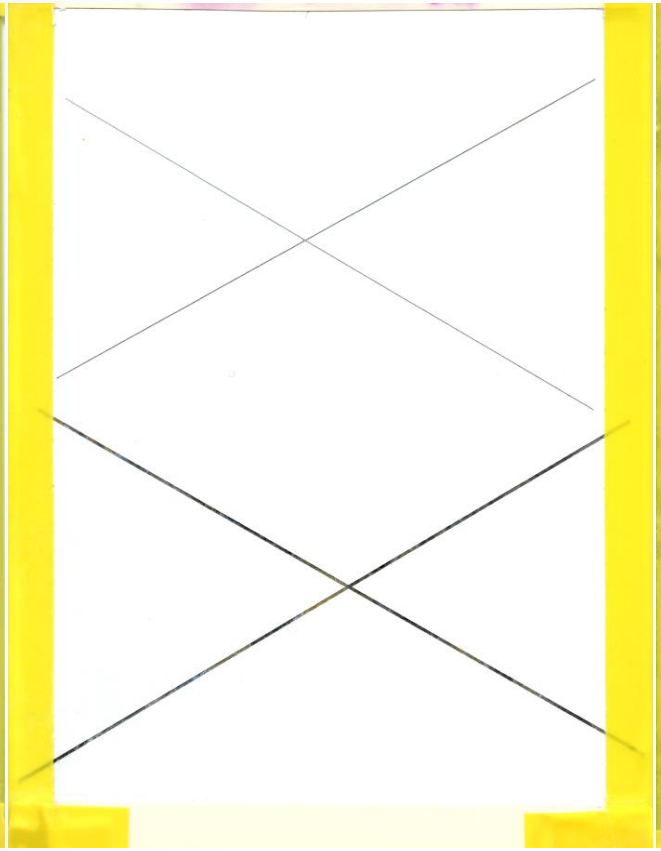


ASTM B117 Exposure 2000+ hours – Testing Continues

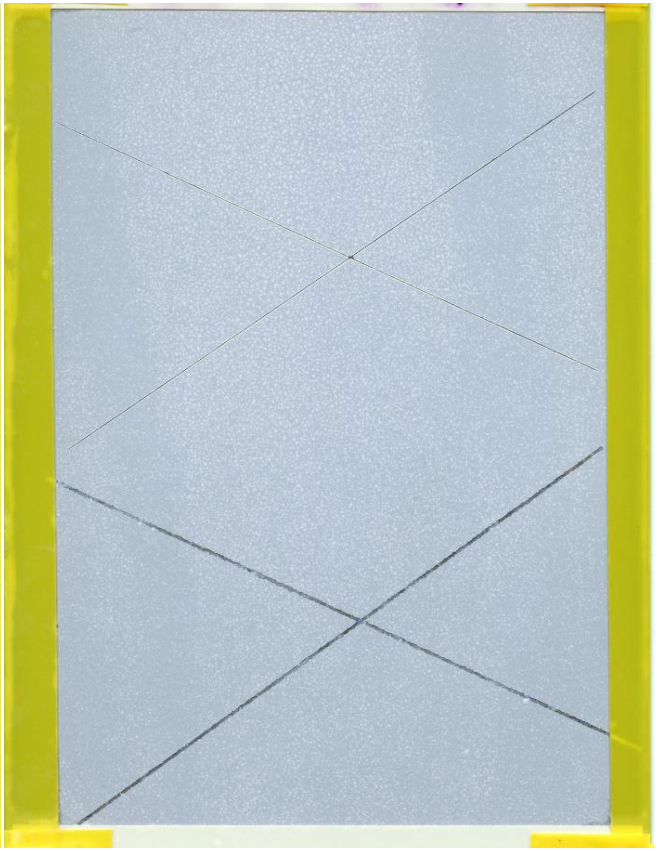
Non-optimized OEM-compounded primers exhibit good performance over both ZnNi and Cd plated steel

Non-Inhibited primer over TCP/ZnNi/4130
2,000hrs ASTM B117

Primed CCC/Cd/4130
2,000hrs ASTM B117



Primed TCP/ZnNi/4130
2,000hrs ASTM B117



Adhesion, Hardness, Solvent, Fluids Testing - Passed

Adhesion

- *Dry and wet (24 hours in DI water) adhesion per ASTM D3330*

Hardness

- *Passed - ASTM D3363*

Solvent resistance

- *MEK per MIL-PRF-23377 (at least 50 passes without primer removal)*

Fluid resistance: 24 hours and 30 days exposure

- *Aeroshell 33 grease*
- *Skydrol – room temp*
- *Super Bee 300 LF alkaline cleaner*
- *SafeWing aircraft de-icer*
- *Aviform runway de-icer,*
- *Jet A1 jet fuel*

Summary – Next Steps

- Primer formulation performing well on both TCP/ZnNi and CCC/Cd steel:
  - Lab-made primer 3,000hrs ASTM B117 – Scribed: No rust
  - OEM-compounded primer >2,000 hours ASTM B117 – Scribed No rust; Exposure continues
- Pigment formulation and loading optimization in progress
- Technology and manufacturing scale-up and maturation to TRL6 by end of 2015
- Field testing and validation to start in 2016